# Small Pipe Characterization System

**A system for conducting characterization and inspection activities within small piping systems from 2-3 inches in diameter.**

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**Participants**
Idaho National Engineering and Environmental Laboratory
Foster Miller, Inc.

**Technology Need**
Conducting characterization and inspection activities within piping systems is critical to comprehensive decontamination and dismantlement activities throughout Department of Energy (DOE) facilities. Technologies exist for characterizing large piping (4" diameter and larger), but the ability to accurately characterize smaller diameter piping was not available. Because contaminated facilities have a wide range of pipe in systems that require characterization, a system that has the capability to enter and inspect small pipe systems was needed to promote inclusive characterization efforts.

**Research Objective**
The research objective of the Small Pipe Characterization System (SPCS) was to develop a robotic system to characterize the internal surfaces of horizontal and vertical piping with an internal diameter of 2-3 inches without removing the system from the pipe for reconfiguration. A further objective was to achieve advances in miniature system components such as cameras, actuators, gears, and power supplies.

**Technology Description**
The SPCS consists of a control computer; a tether for power, video, and data communication; and a pipe-crawling robot. The pipe-crawling robot is driven by dc-motor-powered wheels arranged in a triangular configuration and sprung against the sides of the pipe for traction (see pictures). The configuration of the wheels allow the pipe crawler to adapt to changing pipe diameters "on the fly" without having to manually reconfigure the robot. All of the wheels on the vehicle are steerable to allow the vehicle to rotate in the pipe. This feature allows the vehicle to be aligned for corners or to avoid small obstructions. The vehicle has a small color camera and lights mounted on the front, and can carry a small radiation sensor.

The original system tether consisted of two pairs of very small data wires, two small power wires, and a small multiconductor cable for raw video data, which was processed off-board. An experimental digital, bidirectional fiber-optic tether system was built later to transmit video data, sensor data, robot system status, and robot commands between the control computer and the robot. The tether was designed to pay out fiber from the robot as it traveled down the pipe. On the return trip, the tether was to be pulled from the pipe in front of the robot. A different camera was also repackaged onto the vehicle so that video was processed on-board. The fiberoptic tether worked well for data, but video quality suffered, so the system was returned to its original configuration with a small coax cable replacing the multiconductor video cable.

The SPCS operator station provides real-time video from the vehicle and can display sensor readings along the pipe and relevant system status information. All vehicle functions (light control, speed control, steering control) are available through a graphical user interface (GUI) built in Labview, and an alternate GUI was built using Visual Basic.

**Research Opportunities**
Many opportunities exist for the SPCS since it could be applied to a wide range of applications including applications in private industry. For instance, other characterization sensors could be incorporated onto the vehicle such as polychlorinated biphenyl (PCB) detectors, chemical detectors, and eddy current and ultrasonic sensors.

**Technology Status**
All of the original SPCS technical workscope was completed successfully in 1995. The SPCS was demonstrated for a broad audience in September 1995 at Oak Ridge National Laboratory. At the demonstration the SPCS successfully drove through a piping system with 2" and 3" pipe, around elbows, vertically over 8 feet, and through expanding and reducing fittings. The technology has therefore been proven on a prototype level, but needs some ruggedizing and redesign to be a field-deployable system.

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